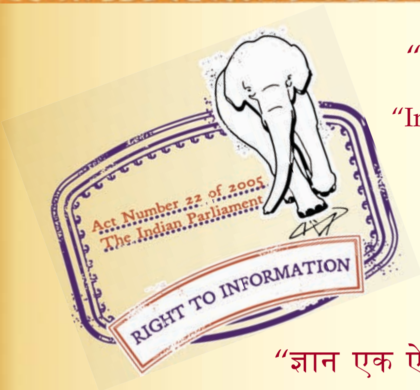
IS 8987 (1978): Recommended practice for air carbon arc gauging and cutting [MTD 12: Welding Applications]



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Indian Standard

RECOMMENDED PRACTICES FOR AIR CARBON ARC GOUGING AND CUTTING

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Indian Standard

RECOMMENDED PRACTICES FOR AIR CARBON ARC GOUGING AND CUTTING

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Indian Standard

RECOMMENDED PRACTICES FOR AIR CARBON ARC GOUGING AND CUTTING

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 25 October 1978, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard is intended to serve as a guide to the use of air carbon-arc process for gouging and cutting of metals, particularly those that are not readily out by the oxygen cutting process.

0.3 This standard is based on AWS C 5·3-74 Recommended practices for air carbon-arc gouging and cutting, published by the American Welding Society, USA.

1. SCOPE

1.1 This standard covers the recommended practices for gouging and cutting of metals by air carbon-arc process.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 812-1957* shall apply.

3. DESCRIPTION OF THE PROCESS

3.1 In the air carbon-arc process severing of metals is effected by melting with the heat of arc between an electrode and the base metal and removing the molten metal by a stream of air. The arc is struck between a special carbon-graphite electrode and the metal to be removed. The electrode is held by a special insulated electrode holder through which air is directed to the arc.

3.2 Power usually supplied from an arc-welding power source is higher than that for a metal-arc welding electrode of comparable diameter.

*Glossary of terms relating to weldng and cutting of metals.

3.3 Although the air carbon arc process is used primarily for gouging and washing off excess metal, it is also used for cutting metals particularly those that are not readily cut by the oxygen cutting process. For these metals the air carbon-arc process is more suitable because it does not depend on oxidation for its operation.

4. ELECTRODES

4.0 The following types of electrodes are used in the air carbon-arc process.

4.1 Copper-Coated Carbon Electrodes (DC) — This type of electrode is most widely used because of its comparatively long life, stable arc characteristics and uniformity in groove profile. These electrodes are made from a special mixture of carbon and graphite bounded with a suitable binder. Baking this mixture at appropriate temperatures produces dense, homogeneous graphite electrodes of low electrical resistance which are then plated with high purity copper of controlled thickness. Jointed electrodes are also available for continuous operation.

4.2 Plain Carbon Electrodes (DC) — This type of electrode is in limited use because of shorter life in comparison to the copper coated electrodes. They are similar to copper coated electrodes except that they do not have the copper coating.

4.3 Copper Coated Carbon Electrodes (AC) — These electrodes are made from a special mixture of carbon and graphite bounded with a suitable binder. Certain rare-earth metals are incorporated to provide arc stabilization for operation with alternating current.

4.4 Flux Coated Steel Electrodes — These electrodes are normally of 6·3 mm diameter and 450 mm long. A bare section in the middle of the length of the electrode provides a gripping area for the electrode holder. The use of these electrodes is limited to cutting high-purity copper and cast iron where the highest current density is required. The finished surface of the grooves made with these electrodes is not as smooth as that made with carbon electrodes.

5. COMPRESSED AIR

5.1 Ordinary compressed air is satisfactory for air carbon-arc gouging and cutting. Pressure between 0·55 and 0·69 MPa* are normally used. Higher pressures can be used but offer little advantage in metal removal efficiency. Pressures as low as 0·28 MPa have been used with some manual torches in field applications where air was supplied in cylinders, but such low pressures are not recommended (*see* Table 1).

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*1MPa = 10·1 972 kgf/cm^2.

TABLE 1 COMPRESSED AIR PRESSURE AND CONSUMPTION RATE FOR VARIOUS ELECTRODE SIZES

(*Clause* 5.1)

Electrode Dia	Air Pressure	Air Consumption	Compressor Rating	
			Intermittent Use	Continuous
(1)	(2)	(3)	(4)	(5)
mm	MPa	l/min	kW	kW
Under 6·3*	0·280†	85	0·19	0·37
Under 6·3*	0·550	255	1·12	2·24
Under 10·0‡	0·550	453	3·73	5·59
Under 20·0§	0·550	821	3·73	5·59
Under 16·0‖	0·550	708	5·59	5·59
Under 16·0¶	0·550	1 444	5·59	7·46
Under 16·0**	0·550	1 416	—	7·46

*Intermitted duty manual torch.
†*See* 5.1.
‡General purpose manual torch.
§Heavy duty manual torch.
‖Semiautomatic mechanized torch.
¶Mechanical feed mechanical torch with auxiliary air for deep grooves.
**Controlled arc mechanized torch.

6. POWER SOURCES

6.1 All standard welding power sources can be used for the air carbon-arc cutting process. However, the open-circuit voltage should be sufficiently higher than the required arc voltage to allow for the voltage drop in the circuit. The arc voltage used in air-arc process ranges from 35 to 56 V. An open circuit voltage of at least 60 V is, therefore, required. The actual arc voltage in the air carbon arc process is governed to a larger extent by the size of the electrode and the application.

6.1.1 The following power sources may be used:

Current	*Type*	*Remarks*
DC	Constant current (motor-generator, rectifier, or resistor grid unit)	Recommended for all electrode sizes
	Constant potential (motor-generator or rectifier)	Recommended for 6·3 mm and larger diameter electrodes only. May cause carbon deposit with small electrodes. Not suitable for automatic torches with voltage control

Current	*Type*	*Remarks*
AC	AC Constant current (transformer)	Recommended for AC electrodes only
	AC-DC	DC supplied from three phase transformer-rectifier supplies is satisfactory, but D from single phase sources gives unsatisfactory arc characteristics. AC output from AC/DC units is satisfactory provided AC electrodes are used

7. CUTTING TORCHES

7.1 Manual Torches — In a manual torch the electrode is held in a rotating head which contains one or more air orifices so that regardless of the angle at which the electrode is set with respect to the electrode holder, air stream is always in perfect alignment. Electrode holders with two heads with a fixed electrode angle are also available for special applications.

7.1.1 Electrode holders are normally air-cooled, but for high current applications water-cooled electrode holders are available.

7.2 Mechanized Torches — The mechanized air-arc gouging and cutting torches are of three types:

a) Torch is mounted on a machine carriage but the electrode feed is manually controlled,

b) Constant mechanical electrode feed type which relies on a spring loaded device to maintain constant arc length for uniform depth of cutting, and

c) In the voltage-controlled automatic type the arc length is maintained by voltage signals through solid state electronic controls. This type is capable of making grooves of consistent depth to a tolerance of $\pm$ 0·6 mm.

8. OPERATING TECHNIQUES

8.1 Manual Gouging — The electrode should be gripped such that a maximum of 150 mm extends from the electrode holder to the work (*see* Fig. 1). For aluminium alloys, this extension should be reduced to 100 mm. Recommended current ranges for various electrode types and sizes are given in Table 2.

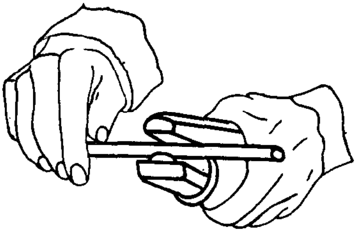

Fig. 1 Positioning Electrode in Electrode Holder

TABLE 2 RECOMMENDED CURRENT RANGES FOR THE COMMONLY USED ELECTRODE TYPES AND SIZES

Electrode Diameter	DC Electrode (Electrode + ve)		DC Electrode (Electrode − ve)		AC Electrode With AC	
	Min	*Max*	*Min*	*Max*	*Min*	*Max*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
mm	A	A	A	A	A	A
4	90	150	—	—	—	—
5	150	200	150	200	150	180
6·3	200	400	200	300	200	250
8·0	250	450	—	—	—	—
10·0	350	600	300	500	300	400
12·5	600	1 000	400	600	400	500
16·0	800	1 200	—	—	—	—
20·0	1 200	1 600	—	—	—	—
25·0	1 800	2 200	—	—	—	—

8.1.1 The air jet should be turned on before gouging, and the electrode holder should be held so that the electrode slopes back from the direction of travel with the air stream behind the electrode (*see* Fig. 2). Under proper operating conditions, the air stream is expected to sweep beneath the electrode end and remove all molten metal. The arc length should, therefore, provide sufficient clearance for this action. The arc may be struck by touching the electrode to the work. The electrode should not be drawn back once the arc is struck. The gouging technique is different from that of arc welding because metal is removed instead of depositing. A short arc should be maintained by progressing in the direction of the cut fast enough to keep up with metal removal. The steadiness of progression controls the smoothness of the resulting cut surface.

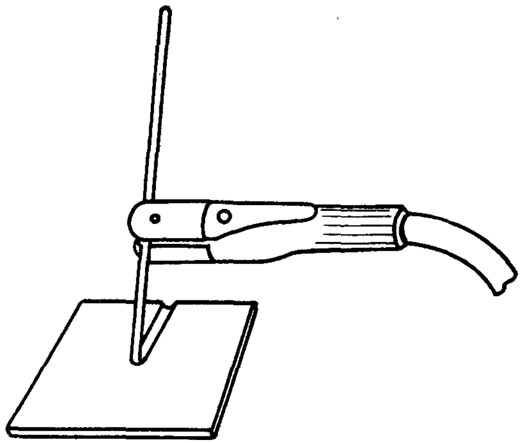

FIG. 2 FLAT POSITION GOUGING

8.1.2 For gouging in the vertical position, the electrode holder should be held as shown in Fig. 3. Gouging should be done in a downward direction. This permits gravity to assist in removing the molten metal. Vertical gouging in the upward direction may be done, but is difficult. Gouging in the horizontal position may be done either to the right or to the left. In gouging to the right the electrode holder should be held as shown in Fig. 4. In gouging to the left the electrode holder should be reversed because the air jet should follow the electrode. For gouging in the over-head position the electrode should be positioned nearly parallel to the electrode holder as shown in Fig. 5. The electrode holder should be held at an angle that will prevent molten metal from dripping on the operator's glove.

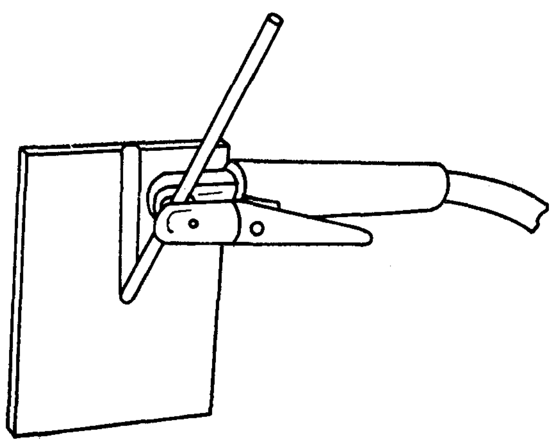

FIG. 3 VERTICAL POSITION GOUGING

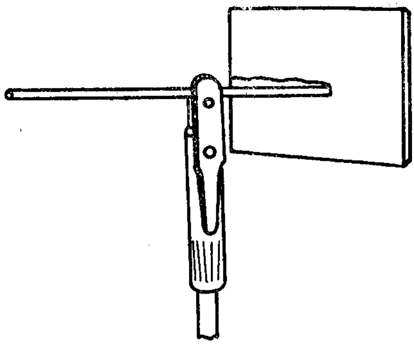

FIG. 4 HORIZONTAL POSITION GOUGING

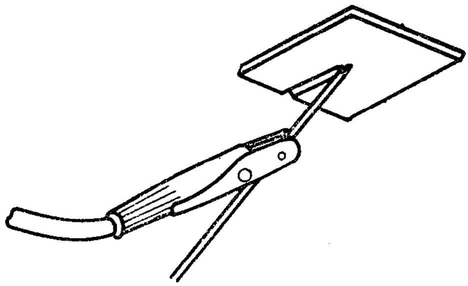

FIG. 5 OVERHEAD POSITON GOUGING

8.1.3 The depth and contour of the groove produced are controlled by the electrode angle and travel speed. Grooves up to 25 mm may be made depending on the skill and experience of the operator. A small lag angle* and slow travel speed will produce a narrow deep groove. A large lag angle and fast speed will produce a wide shallow groove. The width of the groove is detemined by the size of the electrode used, and is usually about 3 mm wider than the electrode diameter. A wider groove can be made with a small electrode that is oscillated in a circular motion or weaved. A steady rest is recommended in gouging to ensure a smoothly gouged surface. It is particularly advantageous in overhead work.

8.1.4 Size of electrode, type of metal amperage and air pressure influence the travel speed. At the properly adjusted travel speed the arc produces a hissing sound and will result in a good cut.

*Lag angle is the angle the eleotrode makes behind a line perpendicular to the cut axis at the point of cutting, taken in a longitudinal plane.

8.2 Mechanized Gouging — Mechanized gouging is similar to manual gouging except that some or all of the operation parameters are mechanized. Typical operating conditions for mechanized gouging are given in Table 3.

9. CUTTING

9.1 In general the technique for cutting is the same as for gouging except that the electrode is held at a steeper lag angle and is directed at a point which will permit the tip of the electrode to pierce the metal being severed (*see* Fig. 6).

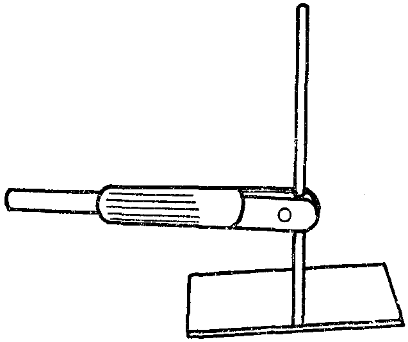

FIG. 6 SEVERING

9.2 For cutting thick non-ferrous metals, the electrode should be held in the vertical position with a lag angle of 45° and with the air jet above it. With the electrode in this position the metal may be cut by moving the arc up and down through the metal with a sawing motion.

10. WASHING

10.1 In using the air-arc process for removing metal from large areas, such as the removal of surfacing and of riser pads on castings, the proper position of the electrode is shown in Fig. 7. The electrode should be weaved from side to side in a forward direction to the depth desired.

10.2 Particularly suited for this application are the electrode holders with fixed position heads which hold the electrode at a fixed angle and direct the air jet below the electrode. With other types of holders, care should be taken to keep the air behind the electrode. The steadiness of the operator determines the smoothness of the surface produced. A lag angle of 55° is recommended.

TABLE 3 TYPICAL OPERATING CONDITIONS FOR MECHANIZED GOUGING

(*Clause* 8.2)

U-Preparation Width	U-Preparation Depth	Electrode Diameter	Current (Electrode + ve)	Voltage	Electrode Feed Rate	Travel Speed	Length of Groove per Electrode
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
mm	mm	mm	A	V	mm/min	mm/min	m
6	1·5	5·0	200	43	160	2080	2·95
7	3·0	5·0	200	40	170	970	1·2
8	5·0	5·0	200	42	170	690	0·88
	6·0 (*see* Note 5)	6·0					
8	2·5	6·3	270	40	102	1 372	3·1
	3·0		300	42	102	1 295	2·95
	5·0		300	40	170	970	1·22
	6·0		320	42	157	750	0·75
	10·0		320	46	91	380	0·90
10	3·0	8·0	320	40	76	1 665	4·97
	5·0		400	46	109	1 168	2·38
	6·0		420	42	97	792	1·83
	12·5		540	42	142	690	1·07
12	3·0	10·0	560	42	107	2 083	4·35
	3·0				84	1 650	4·42
	5·0				66	1 040	4·3
	6·0				76	750	7·23
	12·5				81	380	1·04
	18·0				89	310	1·28
14	3·0	12·5	1 200	45	76	864	2·6
	6·0					560	1·92
	10·0					526	1·45
	12·5					470	1·37
	16·0					380	1·0
	19·0					318	0·75
20	3·0	16	1 300	42	64	1 130	6
	6·0					750	2·6
	10·0					508	1·7
	12·5					368	1·1
	16·0					330	1·07
	19·0					280	0·95
	25·0					254	0·65

NOTE 1 — All values are for copper coated electrodes (DC) using electrode positive.

NOTE 2 — Air pressures throughout are 0·55-0·69 MPa; 0·690 MPa is recommended for 12·5 mm and 16 mm electrodes.

NOTE 3 — A lag angle of 45° is used for these settings, but when jointed electrodes are used, a lag angle of 55° is often preferred.

NOTE 4 — Combination of settings and multiple passes may be used for grooves deeper than 20 mm.

NOTE 5 — To make 6 mm deep groove make two 3 mm runs.

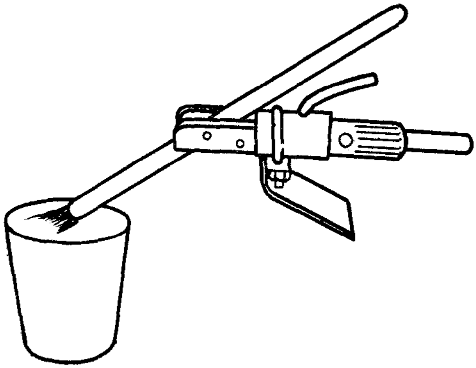

FIG. 7 WASHING

11. BEVELING

11.1 There are two methods of beveling using the air-carbon arc process. In the first method the electrode is held as in Fig. 8A with the air blast between the electrode and the metal surface and is drawn smoothly along the edge being beveled. In the second method which is used for light plates, the electrode is held as in Fig. 8B with the air blast behind the electrode in the direction of travel.

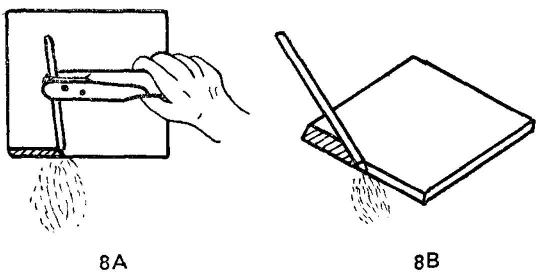

FIG. 8 METHODS OF BEVELING

12. OPERATING TECHNIQUES

12.1 The following techniques are recommended for various base metals:

Base Metal	*Technique*
Carbon steel and low-alloy steel, such as manganese steel	Use dc electrodes with electrode positive, ac electrodes with an ac transformer can be used, but for this application, ac is only 50 percent as efficient as dc

Base Metal	*Technique*
Stainless steel	Apply the same technique as used for carbon steel
Cast iron, including malleable and ductil (nodular)	Use ac electrodes with electrode negative of with ac at the middle of the amperage range. dc electrodes can be used with electrode positive at maximum amperage only
Copper alloys (copper content 60 percent and under)	Use dc electrodes with electrode positive maximum amperage
Copper alloys (copper content over 60 percent or the size of the workpiece is large)	Use ac electrodes with ac
Copper alloys (almost pure copper)	Centre grip steel electrodes may be required
Nialite and superston, special naval propeller alloy	Use dc electrodes with electrode negative
Nickel alloys	Use dc electrodes with ac
Magnesium alloys	Use dc electrodes with electrode positive. Before welding, surface of groove should be wire brushed
Aluminium alloys	Use dc electrodes with electrode positive. Clean the surface prior to welding to render it free from oxide film. Electrode extension (length of electrode between electrode holder and work) must not exceed 100 mm for quality work
Exotic alloys (titanium, zirconium, hafnium and their alloys)	At the present time, these metals cannot be prepared for welding by the air carbon-arc cutting process without subsequent cleaning. They can be cut for remelting.

12.2 Effects of Air Carbon-Arc Process on Base Metals — When the carbon electrode is operated with dc electrode positive (even half cycle of ac when electrode is + ve) the current flow carries ionized carbon atoms from the electrode to the base metal. The free carbon particles are rapidly absorbed by the melted base metal until a high carbon content is reached. Since this absorption cannot be avoided it is important that all

molten, metal (carburized) be removed from the kerf, preferably by the air blast.

12.3 When the air carbon-arc process is used under improper conditions, the molten, carburized metal left behind the kerf or groove may usually be recognized by its dull grey-black colour. This contrasts with the bright blue colour of the properly-made groove. Inadequate air flow may leave small pools of carburized metal in the bottom of the groove. Irregular electrode travel, particularly in a manual operation will produce ripples in the groove wall that tend to trap the carburized metal. An improper electrode angle may cause small beads of carburized metal to remain along the edge of the groove.

12.4 The effect of carburized metal that remains in the kerf through a subsequent welding operation depends upon many factors including the amount of carburized metal present, the welding process to be employed, the kind of base metal, and the weld quality required. Although it seems likely that filler metal deposited during welding would assimitate small pools or beads of carburized metal on a kerf in steel base metal, experience shows that traces of metal containing high carbon content (approximately 1 percent) may remain along the weld bond line. With increasing demands for weld strength and toughness performance these imperfections become more significant stress concentrations.

There is no evidence that the copper from copper coated electrodes is transferred to the kerf surface in the base metal.

Although carburized metal on the kerf surface may be removed by grinding, it is desirable to conduct the air-arc gouging and cutting operations properly within prescribed conditions and thus completely avoid the rentention of this undesirable metal.

Studies conducted on stainless steels have shown no significant difference in the corrosion rates for specimens prepared by air carbon-arc process and those prepared by grinding.

12.5 In comparison to oxygen cutting the air-carbon arc process involves lower energy input. Therefore a workpiece gouged or cut by air-carbon arc process is less distorted.

The machinability of low-carbon and nonhardenable steels is not affected by the air carbon-arc process. With cast iron and high-carbon steels, however this process will generally cause sufficient hardening to make the cut surface non-machinable. Nevertheless, because the heat-affected zone is shallow (approximately 0·15 mm), it is possible for a cutting tool to get under the hardened zone and remove the hardened surface.

13. ADVANTAGES AND LIMITATIONS

13.1 Advantages

a) *Fast* — The air-carbon arc process is five times as fast as chipping. A 10 mm groove can be gouged at 600 mm per minute.

b) *Easily Controllable* — Removes defects with precision. Defects are clearly visible in the groove and can be followed with ease. The depth of cut is easily regulated and welding slag does not deflect or hamper the cutting action.

c) *Low Equipment Cost* — No gas cylinders or regulators are necessary except in field operations.

d) *Economical to Operate* — No oxygen or other fuel gas is required.

e) *Easy to Operate* — The equipment is compact and easy to operate. It can be operated in restricted spaces. It requires no difficult adjustments for use on different metals.

f) *Cuts Cleanly* — Surfaces resulting from this process are clean and smooth. Welding can generally be done without further grinding and machining.

g) *Less Distortion* — Compared to oxygen cutting the air-carbon arc process involves lower energy input. Therefore, a wirepiece gouged or cut by arc-air process is less distorted.

13.2 Limitations

a) For cutting other processes give better results.

b) A large volume of compressed air is required.

c) Surface (skin) hardness increases on cast iron and air hardening metals.

d) There are limitations on depth of cut.

14. SAFETY PRECAUTIONS

14.1 The provisions contained in IS : 818-1968* and IS : 3016-1965† shall apply.

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*Code of practice for safety and health requirements in electric and gas welding and cutting operations (*first revision*).

†Code of practice for fire precautions in welding and cutting operations.

15. PROBLEMS DURING OPERATION

15.1 Some common problems connected with the air-carbon arc process and solution are given below:

Sl No.	*Problem*	*Solution*
1)	Large carbon deposit at the beginning of a groove	The cutting operator either neglected to turn the air jet on before striking the arc, or the torch was positioned improperly. The air should be turned on before striking the arc and should flow between the electrode and the work and behind the electrode in the direction of travel
2)	An unsteady arc; causing the cutting operator to use a slow travel speed even on shallow grooves	The amperage is insufficient for the electrode diameter used (*see* Table 3). While the minimum amperage is sufficient, it does require a higher degree of cutting operator skill. The middle of the range is much more efficient. Therefore, if the amperage is limited by the capability of the power source, greater efficiency can be obtained by dropping down to the next smaller diameter electrode
3)	Erratic groove, with the arc wandering from side to side and with the electrode heating up rapidly	The process was used with deep (electrode negative). dc electrodes should be used with electrode positive on all metals, with the exception of a few copper alloys such as superston and nialite. For these alloys the added heat in the electrode produced by a high amperage for a given electrode diameter seems to increase the cutting speed.

Sl No.	*Problem*	*Solution*
4)	Intermittent arc action resulting in an irregular groove surface	The travel speed is too slow. This is more common in mechanized gouging. However, it may occur in manual gouging if the cutting operator fixes this the speed of air carbon-arc gouging, whether mechanized or manual, is much faster than shielded metal-arc welding. Friction between the gloved hand and the work will cause an erratic forward motion. The cutting operator should assume a comfortable position so that his arms may move freely and his gloves do not drag on the work. If mechanized equipment is involved, check Table 3 for proper operating conditions
5)	In gouging, carbon deposits at varying groove intervals; in pad washing, carbon deposits at various spots on the washed surface	The electrode has stuck to the work. In manual gouging, this condition is caused by using excessive travel speed for the amperage available and for the depth of the groove being made. In mechanized operations, it is caused either by excessive travel speed or by using a flat-curve constant-voltage power source for a small diameter electrode (8·0 mm). In pad washing, this sticking is caused by holding the electrode at too large a lag angle. A lag angle of not more than 65° is recommended. An excessively large lag angle increases the arc area which reduces the current density. This reduction in arc current density requires too great a decrease in the arc length

Sl No.	*Problem*	*Solution*
6)	Irregular groove, too deep, then too shallow	The cutting operator was unsteady. The operator should relax and assume a comfortable position when gouging
7)	Slag adhering to the edges of the groove	Slag ejection was inadequate For adequate slag ejection. proper air pressure and volume, should be used. Air pressure, even between 0·550-0·690 MPa, will not effect ejection of all the slag if the volume is insufficient. Adequate volume requires the air hose feeding the concentric cable assembly to have a minimum initial dia of 6·3 mm for manual torches. For voltage-controlled mechanized torches, a minimum hose initial dia of 12·5 mm is required
8)	Groove gets progressively deeper (except for voltage controlled units)	Either the electrode travel speed is too slow or the electrode feed rate is too high. Table 3 gives the proper travel speed and feed rate that should be used in mechanized gouging. The groove will likewise get deeper if the work is not parallel to the electrode travel. This condition, if present, must be corrected to avoid this particular problem. If a mechanical floating head device is used, the spring should be compressed 1/2 travel to accommodate all surface changes
9)	Groove gets shallower	This is reverse of problem 8 and the same correction should be made

15.2 In summary, the air carbon-arc cutting process is a simple, effective, and economical method of metal removal for weld preparation, back gouging, casting conditioning, stainless and non-ferrous alloy cutting and

defect removal in maintenance operations. It does not require a high degree of cutting operator skill. Properly used, the finished surface can be welded and machined without further preparation.

16. AREAS OF APPLICATION

16.1 Some of the areas in which the air carbon-arc process has been utilized are as follows:

Agriculture	Preparing joints of broken metals on farm machinery for welding. Removal of surfacing. Cutting non-ferrous metals
Aircraft	Maintenance of plane handling equipment and air-port structures. Reworking dies and fixtures
Automotive	Maintenance. Preparation of broken cast iron parts. Cutting non-ferrous metals. Removing broken or frozen bearing races, collars, etc, from shafts
Boiler shops	Removing rivets and defective welds. Preparing cracks for re-welding. Removing tubes from tube sheets
Breweries	Maintenance of equipment, vats piping, etc. Cutting and gouging all types of metals, especially stainless steel
Chemical plants	Preparing equipment and piping of stainless steel and non-ferrous metals for repair and alteration by welding
Construction	Preparation of members for welding. Removal of defects in welds. Fabrication without pre-beveling. Removing fitting-up clips, lifting pad, etc, without damage to pads or structure. Maintenance of equipment
Contractors	Maintenance of equipment. Removal of surfacing, shovel teeth, and stainless steel welds. Preparing cast iron and manganese steel for welding, including repointing dipper teeth. Preparing cast iron for repair by welding
Dredging	Maintenance of equipment. Preparation of manganese steel parts for repair by welding. Removing surfacing for resurfacing
Foundries	Pad washing; cleaning fins and risers. Removing cracks, sand pockets, and other defects from castings. Maintenance of equipment

Surfacing shops	Removal of old surfacing for resurfacing. Preparing stainless and manganese steels for welding. Removing defective welds
Lumber industry	Maintenance of equipment. Removing surfacing for resurfacing. Dismantling of damaged equipment for reuse and preparing cast iron for welding or brazing
Maintenance shops	Dismantling and remodeling equipment. Removing surfacing for resurfacing. Cutting non-ferrous metals. Preparation of damaged areas for repair welding
Army/Marines	Removal of austenitic weld metal. Back gouging welds for welding the second side. Salvaging armor plates. Cutting non-ferrous metals. Removal of defects in welds and castings
Navy/Coast guard	Removal of defects in welds and castings. Back gouging welds for welding the second side. Removal of austenitic weld metals. Removing pad eyes, dogs, etc, without damage to attachments or to existing structures. Edge preparation of light plate. Removing eroded areas in ship's hulls, stern tubes, struts, skegs, rudders, and propellers for repair by welding. Removal of bulk-heads, patches, and access hatches to reuse for damage control
Mining	Maintenance of equipment. Cutting manganese stocks, cast iron, and all non-ferrous metals. Removal of surfacing
Oil refineries	Removing defective welds. Cutting and gouging stainless and austenitic welds. Cutting out and/or patching tank bottoms and coke and pipe stills. Removing liners, boiler and heat exchanger tubes, and rivets. Removing defects and preparing breaks in castings for repair by welding. Cutting non-ferrous metals. Removing risers on castings. Preparing the surface of eroded and corroded areas on acid plant equipment for rebuilding by welding
Oil drilling	Edge preparation for welding of plates and shapes. Removing drill collars. Removal of surfacing for resurfacing. Gouging out defects and preparing edges of castings (mud pumps), etc. Maintenance of equipment. Removal of fish plates on truck chassis for renewal. Preparation of broken edges for rewelding

Packing houses	Preparing equipment vats, and piping of stainless steel and non-ferrous metals for welding
Paper mills	Preparing equipment vats, and piping of stainless steel and non-ferrous metals for welding
Power plants	Maintenance of equipment. Edge preparation of metal for welding. Veeing out castings for repair. Removal of cavitations from Pelton Wheels. Removal of welded end tubes from tube sheets. Removal of welding defects. Cutting and preparing cast iron for welding or brazing
Railroads	Maintenance of equipment. Removal of journal liners, rivets, welded-end tubes from tube sheets. Preparation of breaks in boilers, fire boxes, etc, for repair by welding. As salvage and rescue tool after wreckage of equipment. Preparation for surfacing or its removal from frogs, switches, and rail ends. Preparing manganese steel for welding without harm to mechanical properties. Removal of riser pads and defects from castings in foundries. Preparing worn wheels for rebuilding by welding
Salvage yards	Cutting all scrap. Removing welds without injuring structure for reuse. Cutting all types of stainless steel, non-ferrous metals, and cast iron
Shipbuilding	*See* Navy/Coast guard
Stainless shops	Cutting stainless steel. Removing defects in stainless steel castings
Steel fabricators	Welding and fitting plates without pre-beveling by gouging the second side to sound metal after welding the first side. Removal of welds from existing structures and salvaging undamaged material for reuse. Cutting and gouging all metals in the shop and at the job site. Maintenance of equipment
Steel mills	Maintenance of equipment. Cutting and gouging all metals. Scarfing billets, blooms. Removal of plate defects

Waterworks	Preparation of broken equipment for repair by welding. Cutting and gouging all metals. Cutting cast iron pipe, especially concrete lined. Removal of defective pipe sections for installation of new sections by removing welds
Welding shops	Removing welds. Cutting all metals, especially non-ferrous metals, stainless steel, and cast iron. Preparing bevels and back-gouging roots of welds. Removal of surfacing for resurfacing.

(*Continued from page* 2)

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INDIAN STANDARDS

ON

WELDING

IS:

819-1957	Code of practice for resistance spot welding for light assemblies in mild steel
823-1964	Code of procedure for manual metal arc welding of mild steel
1261-1959	Code of practice for seam welding in mild steel
2811-1964	Recommendations for manual tungsten inert-gas arc welding of stainless steel
2812-1964	Recommendations for manual tungsten inert-gas arc welding of aluminium and aluminium alloys
3023-1965	Recommended practice for building up by metal spraying
4353-1967	Recomendations for submerged-arc welding of mild steel and low alloy steels
4944-1968	Code of procedure for welding at low ambient temperatures
5139-1969	Recommended procedure for repair of grey iron castings by oxy-acetylene and manual metal arc welding
5530-1969	Code of procedure for repair and rectification of steel casting by metal arc welding process
6409-1971	Code of practice for oxy-acetylene flame cleaning
6916-1973	Code of practice for fabrication welding of steel casting
8002-1976	Recommended procedure for welding of flexible PVC
8004-1976	Recommended procedure for welding of rigid PVC
8455-1977	Recommended procedure for welding of polyethlene